CONCLUSIONS BASED UPON OBSERVATION OF FIVE HUNDRED CASES OF FRACTURED SKULL.*

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During the past seven years, while engaged in work at the St. Louis City Hospital, opportunity was offered for observing several hundred cases of fracture of the skull. All classes of fracture and injury were met with, and among the number were many interesting and remarkable cases. In treating the subject, it is intended rather to convey impressions or conclusions that have been formed from an experience with this class of cases than to enter into a statistical study.

In order to obtain a definite understanding of fractures of the skull it is necessary to study these conditions at the autopsy table and in the operating room. Valuable points of surgical and neurological interest may be gathered in this way, and one is often surprised to learn that lesions apparently insignificant and giving little visible indication of trouble have been the cause of such profound and serious symptoms. It becomes necessary at once to differentiate between those injuries which are epidural in character and those which primarily or secondarily affect the brain and its coverings. The brain, when injured, may be subject to contusions, lacerations, hemorrhages, softenings, œdema, anæmia and to nutritional changes.

In postmortems the gross changes, due to hemorrhages, softening, œdema, etc., are easily noticed, but alterations in the more minute structures are often overlooked and the brain is considered normal when in reality it has been the cause of grave symptoms. It is very probable, as Phelps (Ann. Surg., Dec., 1906,) has indicated, that nutritional changes in brain structures are often the result of injury to the organ, and that these changes are of such a complex nature that a definite neurological picture can not be obtained. This observation seems an important one, for it serves to explain the trouble in many cases, and should always receive consideration from the standpoint of prognosis and treatment. Apparently these nutritional changes, as a result of trauma, may be confined to localized areas of the brain independent of gross lesions, just as if they were brought about by pressure.

Fracture of the skull by contre-coup is well recognized, but the fact that the brain may also be injured by contre-coup is not sufficiently appreciated, and not infrequently softening or abscess of the brain develops on the side opposite to the injury on the skull. Contusions of the brain, with resulting effusion of blood or of serum and œdema, are a frequent accompaniment of fracture of the skull and may be present even without fracture. At operation the subdural space often contains fluid under pressure, which fluid may be bloody or clear in character.

Where there is epidural hemorrhage, the clot which forms may cause considerable compression of the brain. If the clot or blood is removed soon after the receipt of injury, the brain thus compressed may react, regain its former shape and show pulsation. If, however, compression has existed for some time, the brain, in most cases, does not react, the area of compression remains, the dura becomes flaccid and pulsations are usually absent. In operations shortly after the time of injury the blood and clot may be easily removed, and it is often forced out through the trephine opening by the intracranial pressure. In operations that are deferred to a later period, the clot is found to be less easily removed and often becomes densely adherent to the dura.

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*Read before the Southern Surgical and Gynecological Society, St. Louis, Dec. 15, 1908.

Where compression of brain tissue is more or less acute and is permanent, the brain usually does not react, and destruction of brain tissue and impairment of functions result. Where the compression is gradual and of a chronic nature, the brain may be given an opportunity to react and the lesions become more localized.

It is evident that the symptoms of fracture of the skull depend rather upon involvement of the brain than upon injury to the cranial bones, and in all cases of fracture or of suspected fracture of the skull, a careful neurological examination is demanded. While the neurological findings are important, they are not always reliable or conclusive as indicative of the location of injury, because often in injury to the skull and the brain the lesions are of a complex nature and are multiple, or they may be remote from the seat of injury. The external evidence of fracture of skull may be slight, and yet later the patient may show grave symptoms of injury. In most cases where there is fracture and the patient is conscious, pain may be elicited over the site of fracture, though hematoma or other evidence be lacking.

The symptom of pain on pressure over an area of the scalp, especially in older and in doubtful cases, is an important sign, and frequently indicates linear fracture of the skull. Hemorrhages into the orbital tissues are frequently mistaken for "black eye," and the direct result of external violence, when in reality they are due to fracture of the skull. Sometimes a "crack-pot" sound may be elicited by percussion, especially when the skull itself has been laid bare.

When the body has been the active agent in producing a fracture, such as would occur in a fall from sufficient height, the symptoms are usually pronounced, while in many cases in which the body has been passive and the fracture is the result of a blow, the initial symptoms may be very insignificant. In certain instances the bony structure is of sufficient resistance to permit little damage to the skull, the force being spent so as to damage principally brain structures, while in other cases the skull is the chief seat of injury, the force of the shock affecting the brain but little.

Fractures of the skull, especially when the base is involved, are usually accompanied by mental disturbance, and in serious cases the patient is unconscious or semiconscious. Unconsciousness coming on shortly after injury is only of relative value, and is not always indicative of the seriousness of the injury. If unconsciousness is followed by a period of consciousness and later again by unconsciousness, it usually indicates that there is serious brain disturbance. With a patient having the advantage of rest, and if consciousness be followed by an unconscious period, the symptom should be regarded as an important one of serious injury. Unconsciousness and confusion of mind often come on as a result of slow hemorrhage or breaking down of brain tissue, and such patients may be restless and appear drowsy, stupid and apathetic. In children, when the head is injured, convulsions are not uncommonly met with, but may be no indication of the seriousness of the injury. In adults status epilepticus is sometimes encountered, which should be seriously regarded when it occurs shortly after injury.

Serious fractures are accompanied by shock and in the early stage the body temperature is normal or frequently subnormal. The pulse is more frequently slow, full and strong. The respiration is often but little altered, except in moribund cases, when it is apt to be labored or stertorous. Vomiting may occur in many cases, and in unconscious cases there is frequently difficulty in swallowing. Where the injury is localized the neurological examination is of great value in eliciting focal symptoms.

In all cases of head injuries and resulting mental disturbance, it is important to know whether or not the skull has been fractured. The knowledge of an existing fracture of the skull is of distinct diagnostic value. The diagnosis may be arrived at by methods of neurological examination or by ocular demonstration. In lacerated scalp wounds the nature of the fracture may often be demonstrated. In fracture of the base there may be bleeding into the orbital tissue and from the nose, mouth or ears, but in these instances careful examination should be made to exclude hemorrhage of these organs from other causes. The demonstration of cerebrospinal fluid is evidence of fracture of the skull. Where the scalp is intact, exploratory incision over hematomata or painful areas is indicated as strongly as are exploratory punctures or incisions for purposes of diagnosis of conditions in other parts of the body. Exploratory incision often gives additional and valuable information, and as a rule the periosteum is found to have been loosened if fracture is present. The location and the direction of lines of fracture and the extent and the nature of the injury to the skull may serve to explain many of the neurological symptoms.

If the brain is uninjured, the neurological symptoms may be wanting, and the diagnosis must be based upon direct examination. It is important to differentiate between concussion, contusions or other injuries to the brain, and those symptoms which are the result of compression due principally to hemorrhage. At times, however, this is impossible, and certain cases with symptoms of contused brain can not be diagnosed from those in which there is hemorrhage with compression. Spinal punctures have a certain diagnostic value as an index of the character of the fluid and the degree of tension.

Great difficulty may be encountered in determining the source of a suspected hemorrhage, because focal symptoms which are present when the hemorrhage is small and localized disappear when the hemorrhage increases and the brain becomes more extensively compressed. As the symptoms of compression increase, the patient may pass from a condition in which the mind is confused to one of unconsciousness.

In the early stages of fracture of the base there may be shock, subnormal temperature, slow and full pulse, regular or labored respiration, vomiting, visible evidences of fracture, unconsciousness, restlessness, and in general diminished or altered reflexes.

Intracranial pressure in the early stage may be chracterized by impaired mental state, restlessness, regular respiration, a full pulse and reflexes pointing to focal symptoms.

In fatal cases, and in later stages of serious cases of fracture, the temperature may be elevated and the volume of the pulse diminished. In uncertain cases it is important to differentiate fracture of the skull from uraemia, apoplexy and alcoholism.

In cases of fracture of the skull the prognosis should be guarded, at least for the first few days. Cases seriously injured and suffering from shock usually die within forty-eight hours. Certain cases do well for a few days and then suddenly and unexpectedly die. The prognosis is much worse when subdural complications exist, than when the injury is extradural. Injury to the dura mater may lead to serious complications. Unconsciousness in itself is not of much value as an indication of the patient's condition, but when the reflexes are present and about normal the prognosis is good. In those cases that react the pulse and temperature remain nearly normal, but when the volume of the pulse diminishes and rate is increased and there is decided elevation of temperature, the prognosis is very bad and a fatal issue usually ensues.

In the treatment of fracture of the skull we should distinguish between surgical and neurological indications for operation. The neurological signs may not be pronounced, yet surgical intervention be distinctly indicated, while on the other hand the surgical aspect may not be emphasized, and yet the neurological findings be definite and conclusive. The neurological condition being subject to changes it is demanded that the patient be kept under continuous observation. When possible, the scalp having been properly prepared, the existence of the fracture and its nature and extent should be determined by exploratory incision, if necessary. Simple linear fractures of the vault, when not causing complicating symptoms, require but little surgical treatment. In depressed fractures the depression should be raised, and all pressure on the dura mater should be removed. When the depression is complicated by comminuation, effort should be made to retain fragments, so that the bony deficiency may be limited as much as possible. Examination should be made for epidural hemorrhage and clot, and, if necessary, drainage instituted. By puncturing the dura the character of the cerebrospinal fluid may be ascertained. If the dura has been injured, it should usually be sutured if possible, and if bulging of dura is due to tension of the cerebrospinal fluid, this may be relieved by spinal puncture. Depressed bone should always be elevated or removed, since pressure and irritation are frequently the cause of convulsions.

The operation should be directed primarily to the relief of brain compression, which may be due to hemorrhage or to blood clot. As a rule, the sooner the blood or clot causing pressure is removed, the better will be the prognosis, and when removed the danger of sequelæ may be avoided. Moreover, old clot is removed with greater difficulty. If large accumulations of blood and clot causing compression are not early removed, the brain will not react and death may result. Therefore, when signs of compression are present, early operation is indicated.

In doubtful cases where the symptom complex of the neurological findings is such that focal symptoms are lacking, exploratory operations are indicated, and it is often better to explore than to wait for symptoms, which, when they become manifest, are the result of brain compression and the destruction of brain tissue.

With improvements in methods of technique, the danger and complications of operation will be lessened, and the indications for early cranial surgery in doubtful cases may become as urgent as they are in doubtful intra-abdominal conditions where laparotomy is resorted to. While it is usually better to explore early than late, in a certain class of doubtful cases it may be better to wait, the time for operative interference being indicated by a rise in temperature and diminished blood pressure. In fractures at the base, where the symptoms point to nutritional changes and extensive destruction of brain tissue, operation is not indicated, but where there are distinct signs of hemorrhage and pressure, operative procedure, with drainage of the middle fossa, has given good results.

Bone deficiencies are often an annoyance to the patient when recovery takes place and, therefore, when time is not too great a factor the bone flap operations are to be preferred. In cranial surgery of an emergency character, additional shock should be avoided, and the control of hemorrhage and the duration of operation are important factors.

Experience has shown that in compound

fractures and in injuries to dura or brain thorough drainage of the wound is important.

Aside from elimination and remedies influencing blood pressure, therapeutic measures seem to be of little value in fracture of the skull. In all cases rest is important, and patients should not be allowed to get out of bed for a number of days.

CONCLUSIONS.

Linear fractures of the vault usually do not require operation, unless they involve important vessels or sinuses.

In depressed fractures, the fragments causing compression should be elevated or removed.

Experience has shown that in compound fractures, especially where there is injury to dura or brain, drainage of the wound is usually desirable.

Operation for fracture at the base is indicated where hemorrhage is extradural, and where there are signs of compression. The middle fossa is most frequently involved, and drainage here can be easily instituted.

The practice of examining hematomata by means of exploratory incision when reasonable precautions are taken is practically without danger, and often gives most valuable information as an aid in diagnosis.

The neurological findings are of value in determining focal symptoms, but when complex brain disturbances exist they may be unreliable as diagnostic aids, and require special interpretation.

Brain compression is a positive indication for operation, and, as a rule, the sooner compression is removed the better the prognosis.

At operation shock and hemorrhage are factors that should be carefully regarded, and operation should be done as speedily as possible.

In doubtful cases, where it is probable that the symptoms are caused by brain compression, exploratory operations are indicated.

The expectant treatment is to be advocated in those cases in which there are no symptoms of brain compression, in which the temperature and pulse remain nearly normal, and in which the reflexes are but little altered. Unconsciousness in itself is no index of the seriousness of the trouble.

Operation is contraindicated in those cases in which the symptoms are the result of intrinsic destruction of brain tissue, when the temperature is high, where the pulse is rapid and the blood pressure diminished.

The importance of a longer period of rest in bed should be more strongly emphasized, so that the danger of secondary complications may be avoided.